The information contained in Chapter Six: The Typical Roadway Cross-Section, dated February 2016, has been updated to reflect the July 2017 Errata. The errata addresses errors, changes in procedure, changes in NDOT department titles, changes in other Roadway Design Manual chapters and other reference material citations which have occurred since the latest publication of this chapter.

Chapter Six presents guidance for the design of new and reconstructed projects; design guidance for 3R projects is provided in Chapter Seventeen. This chapter replaces Chapter Six: The Typical Roadway Cross-Section, dated July 2006. This chapter also supersedes Nebraska Department of Transportation Policy Letter DES 09-02: "Curb Location at Edge of Shoulder" dated May 20, 2009 and incorporates the Nebraska Department of Transportation Policy Letter DES 13-01 R1: "Policy for the Installation of the Beveled Edge" dated June 19, 2014. This chapter was approved by the Nebraska Division of the FHWA for use on the National Highway System and other federal projects on February 18, 2016.

Chapter Six
The Typical Roadway Cross-Section

The **Nebraska Department of Transportation** (**NDOT**) typical roadway cross-sections are presented in EXHIBITS 6.1 THROUGH 6.10 and EXHIBITS 6.12 THROUGH 6.14. Variations from these typical sections must be documented by the designer and submitted to the **Assistant Design Engineer** (**ADE**) for approval and to the **Traffic Engineering Division** (**Traffic Engineering**) for concurrence.

For additional information regarding roadway cross-section elements, see Chapter 4 of A Policy on Geometric Design of Highways and Streets (the *Green Book*) (Ref. 6.1).

1. THE TRAVELED WAY

1.A Travel Lane Widths

Lane width is determined by the roadway functional classification, traffic volumes, and design speed. The minimum lane widths are provided in the Nebraska Minimum Design Standards (*MDS*) (Ref. 6.2) (http://www.roads.nebraska.gov/business-center/lpa/boards-liaison/design-standards/) and in Appendix H, "Application of Design Standards"; the typical through lane width is 12 feet for rural and high-speed municipal roadways; low-speed municipal roadways are typically 11 feet in width.

1.B Travel Lane Cross Slopes

A crowned roadway cross-section "breaks" at the high point of the roadway, sloping to both shoulders, typically at a 2% cross slope (See EXHIBITS 6.1, 6.3, 6.5, 6.7 THROUGH 6.10, 6.12 AND 6.13). The high point of a non-superelevated crowned cross-section is usually located at the centerline of the roadway (for two-lane roadways) and at the centerline of the directional travel lanes (for multi-lane highways). Crowned cross-sections are preferred for two-lane roadways and for multi-lane divided roadways with depressed medians. The crowned cross-section allows for drainage to both sides of the roadway surface.

The tangent typical cross-section usually has the high point of the pavement on the inside (median) edge of the inner travel lane and slopes continuously across the travel lanes, typically at a 2% cross slope (See EXHIBITS 6.2, 6.6 AND 6.14). Tangent cross-sections are typically used for multi-lane divided roadways where there is a raised or flush median or where future lanes are to be added to the median (See EXHIBIT 6.11).

2. SHOULDERS

2.A Shoulder Width and Type

Shoulder width and type is based upon the roadway functional classification, traffic volumes, and design speed. Minimum shoulder widths are provided in the *MDS* (Ref. 6.2) and in Appendix H, "Application of Design Standards".

When turf shoulders are built adjacent to concrete lanes or shoulders, the **NDOT** prefers that an additional two feet of turf shoulder width be provided beyond the typical turf shoulder width given in EXHIBITS 6.1 THROUGH 6.10. This added width will allow a two foot minimum turf shoulder to be maintained after future overlay surfacing.

2.B Shoulder Cross Slopes

The cross slope of the shoulder is based upon the functional classification of the roadway and the type of shoulder construction (paved or turf). Typically, shoulder cross slopes for rural roadways are 4% for surfaced shoulders and 6% for turf shoulders.

Surfaced median shoulders which are four feet wide and are of the same surfacing material as the traffic lanes should be at the same cross slope as the adjacent traffic lane. Wider shoulders and shoulders of a different surfacing material than the traffic lanes should slope away from the traffic lanes for drainage, typically at a 4% cross slope.

See EXHIBITS 6.1 THROUGH 6.10 for typical shoulder cross slopes.

2.C Beveled Edge

A beveled edge may allow a smoother return to the roadway when a vehicle has departed the surfacing. The beveled edge will be installed on rural high-speed (V ≥ 50 mph) highways in the following conditions:

1. The project includes surfacing placement of two inches or greater.
2. Surfaced shoulders are less than six feet in width, not including segments of erosion control curbed shoulders.
3. On the inside (median) shoulders of Interstates, freeways and expressways with depressed medians.
4. The roadway is not curbed.
5. In other locations as determined by **Traffic Engineering**.

The type of beveled edge to be used is based upon the project type and surfacing recommendation. See Appendix I, "Installation of the Beveled Edge", for additional information and beveled edge details.

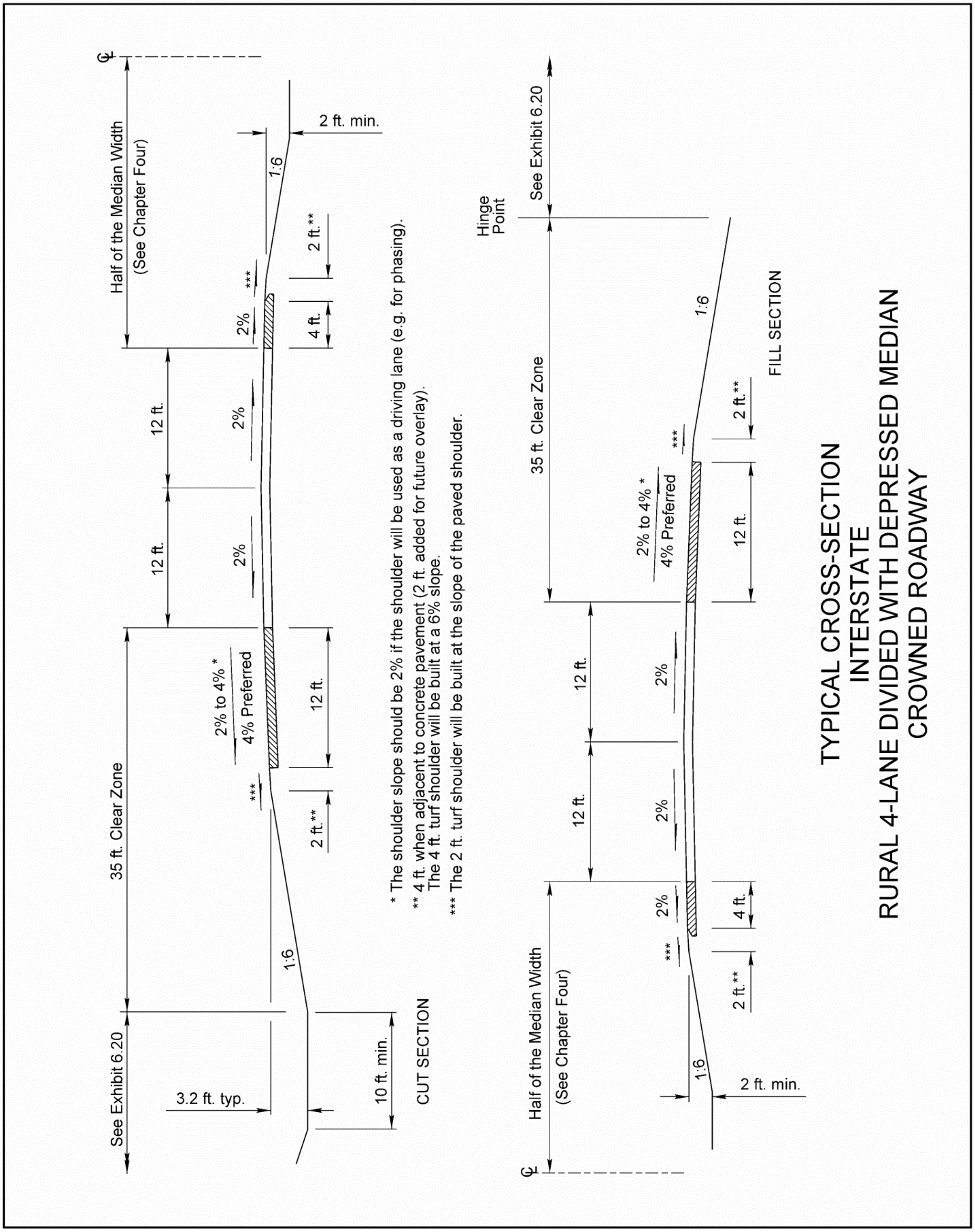


Exhibit 6.1 Typical Section - Rural Four-Lane Divided Interstate with Depressed Median (Crowned Roadway)

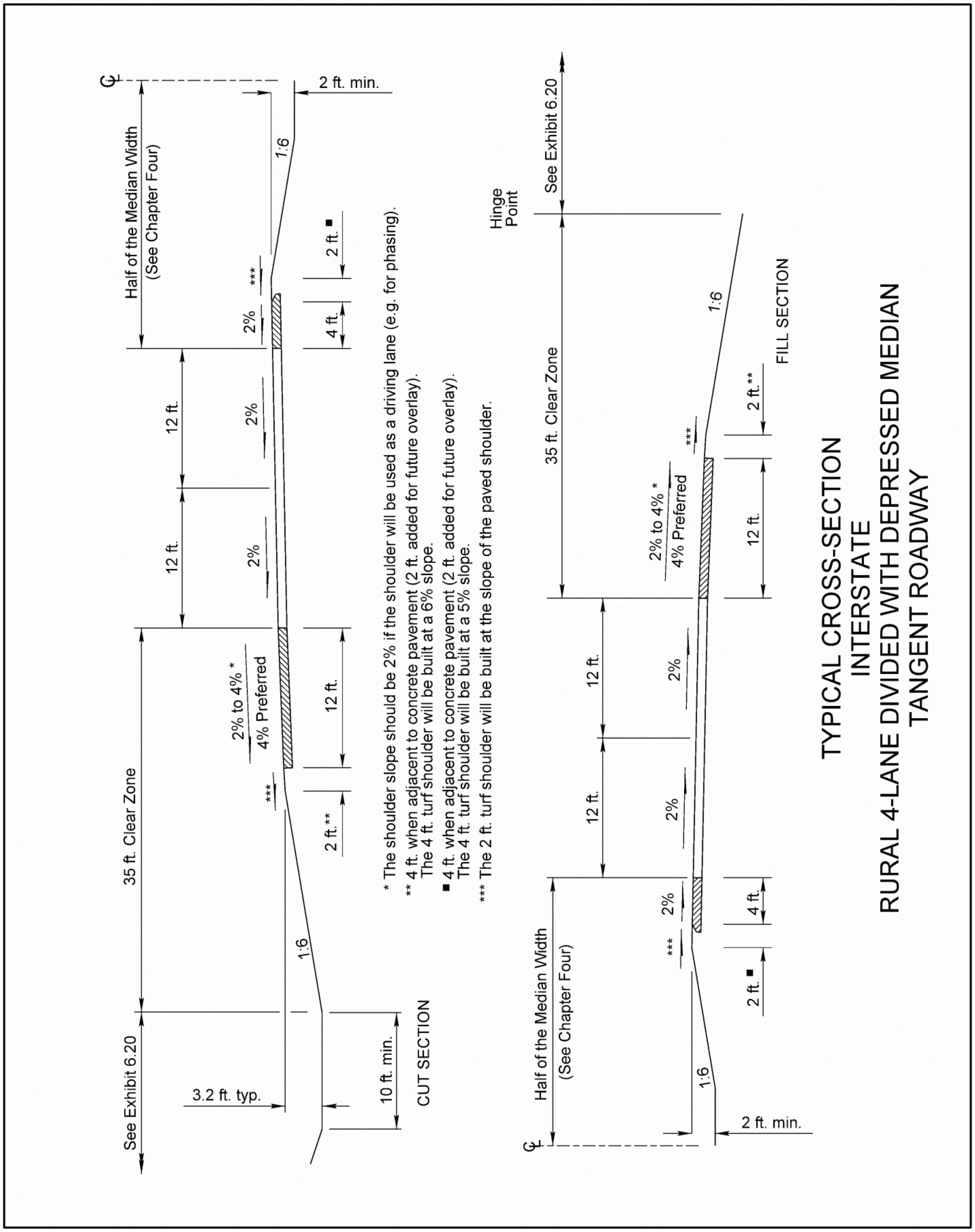


Exhibit 6.2 Typical Section - Rural Four-Lane Divided Interstate with Depressed Median (Tangent Roadway)

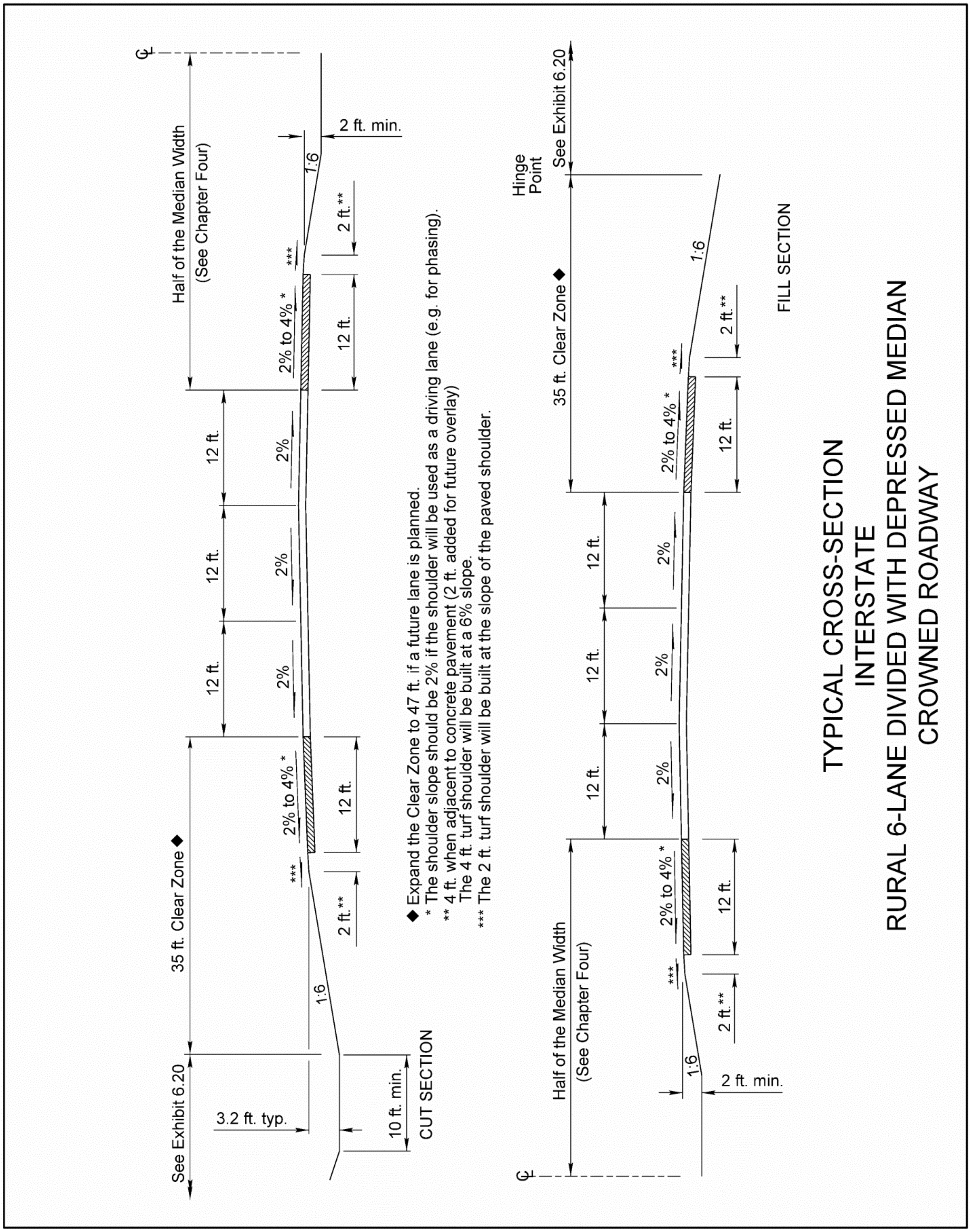


Exhibit 6.3 Typical Section - Rural Six-Lane Divided Interstate with Depressed Median (Crowned Roadway)

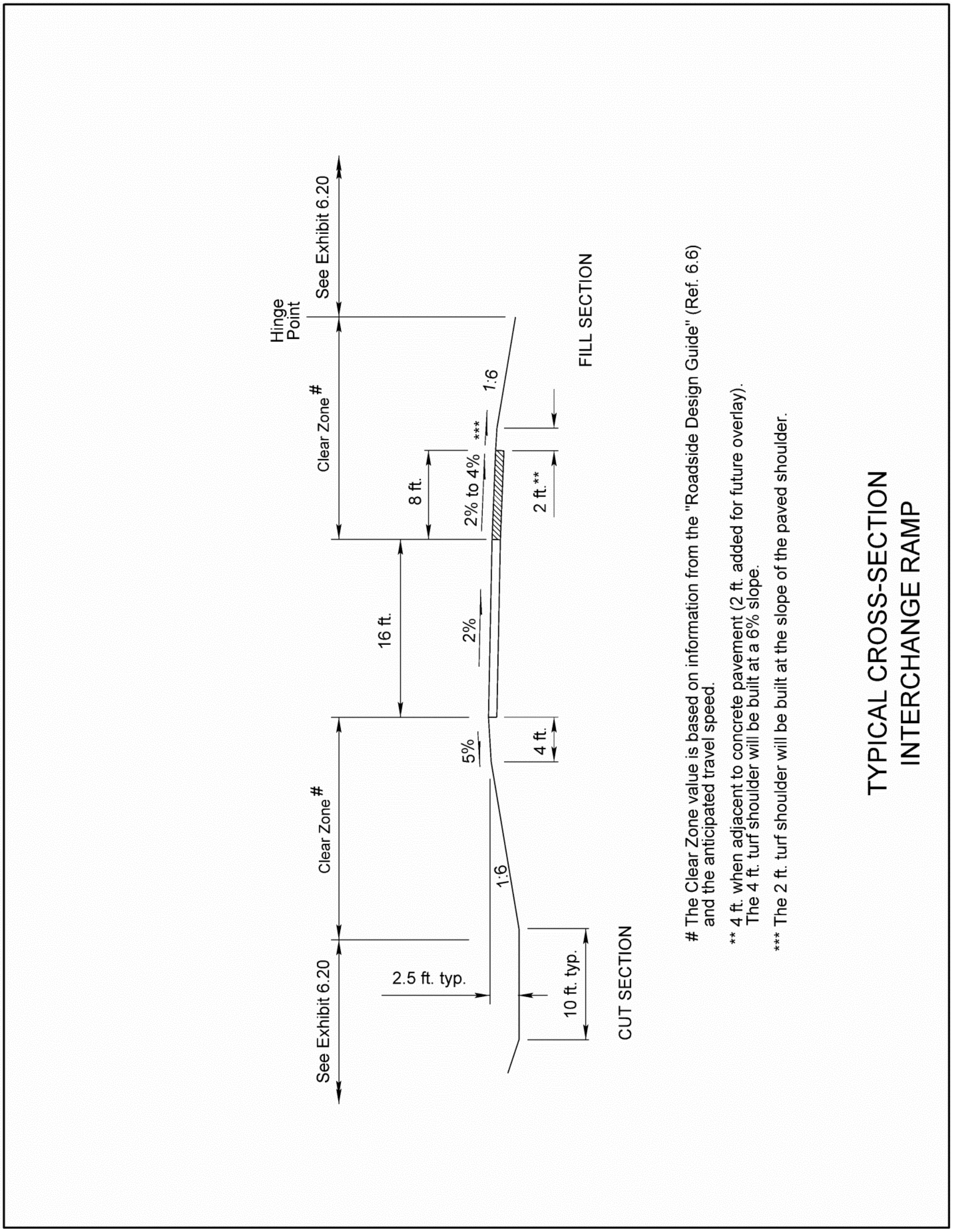


Exhibit 6.4 Typical Section of an Interchange Ramp

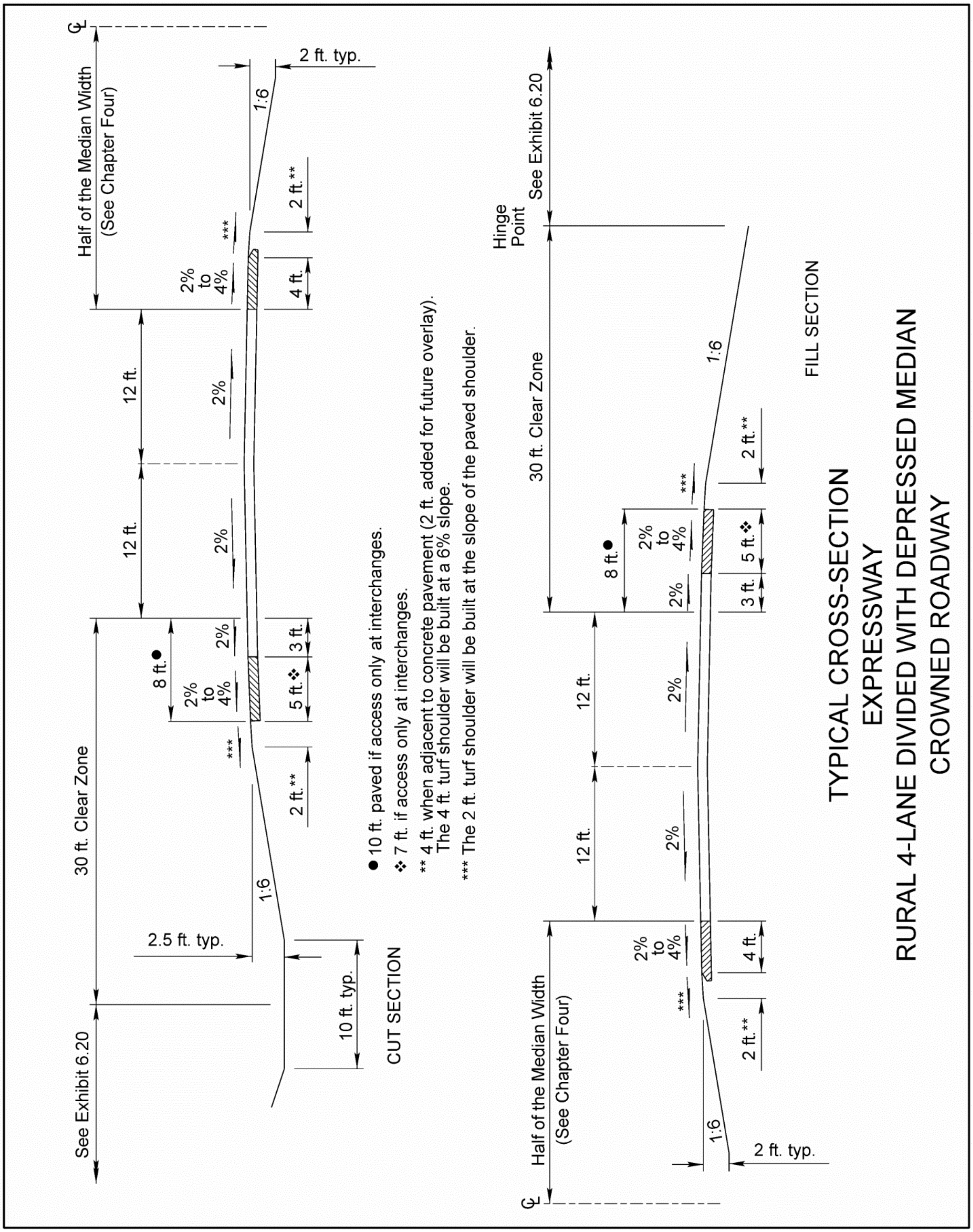


Exhibit 6.5 Typical Section - Rural Four-Lane Divided Expressway with Depressed Median (Crowned Roadway)

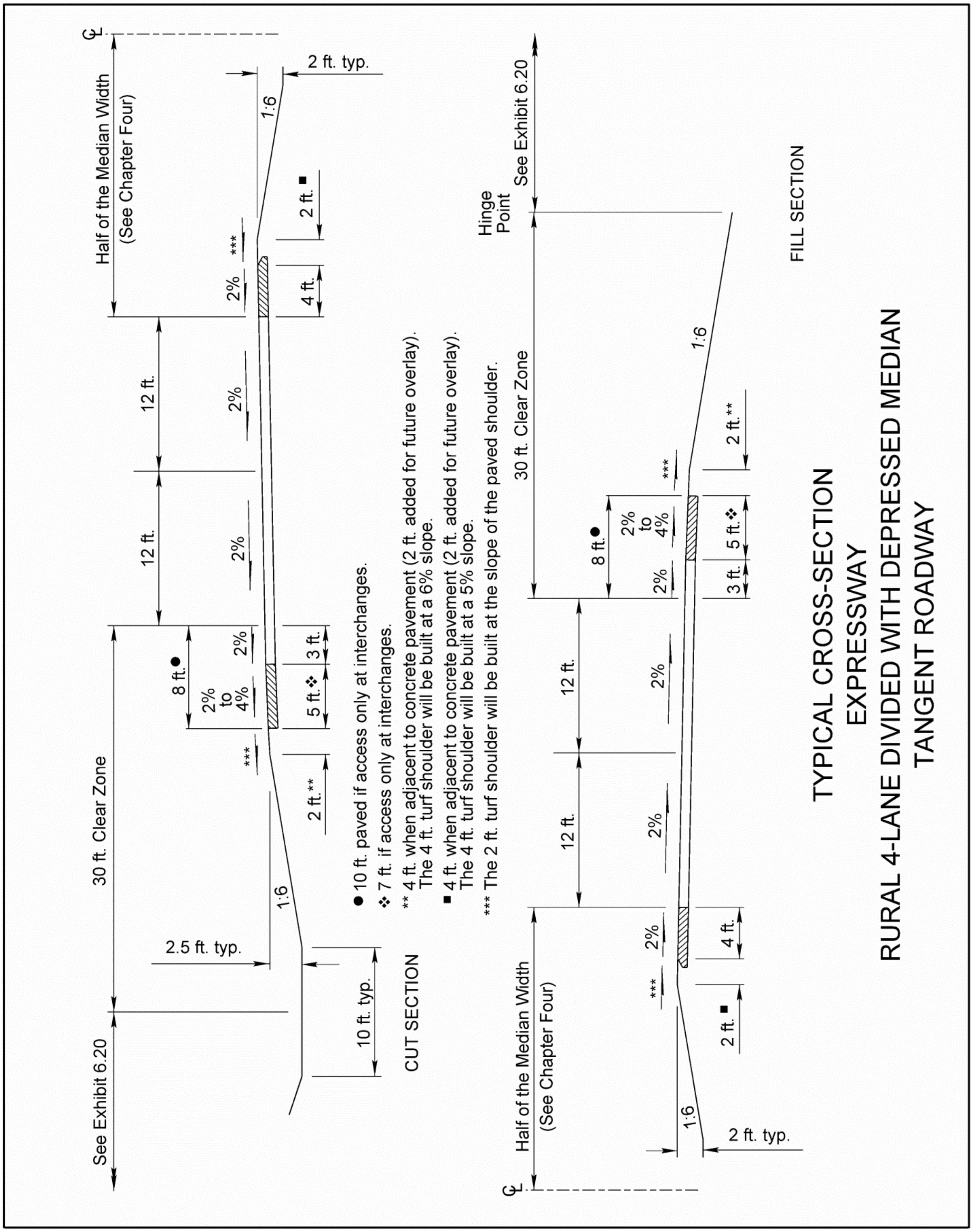


Exhibit 6.6 Typical Section - Rural Four-Lane Divided Expressway with Depressed Median (Tangent Roadway)

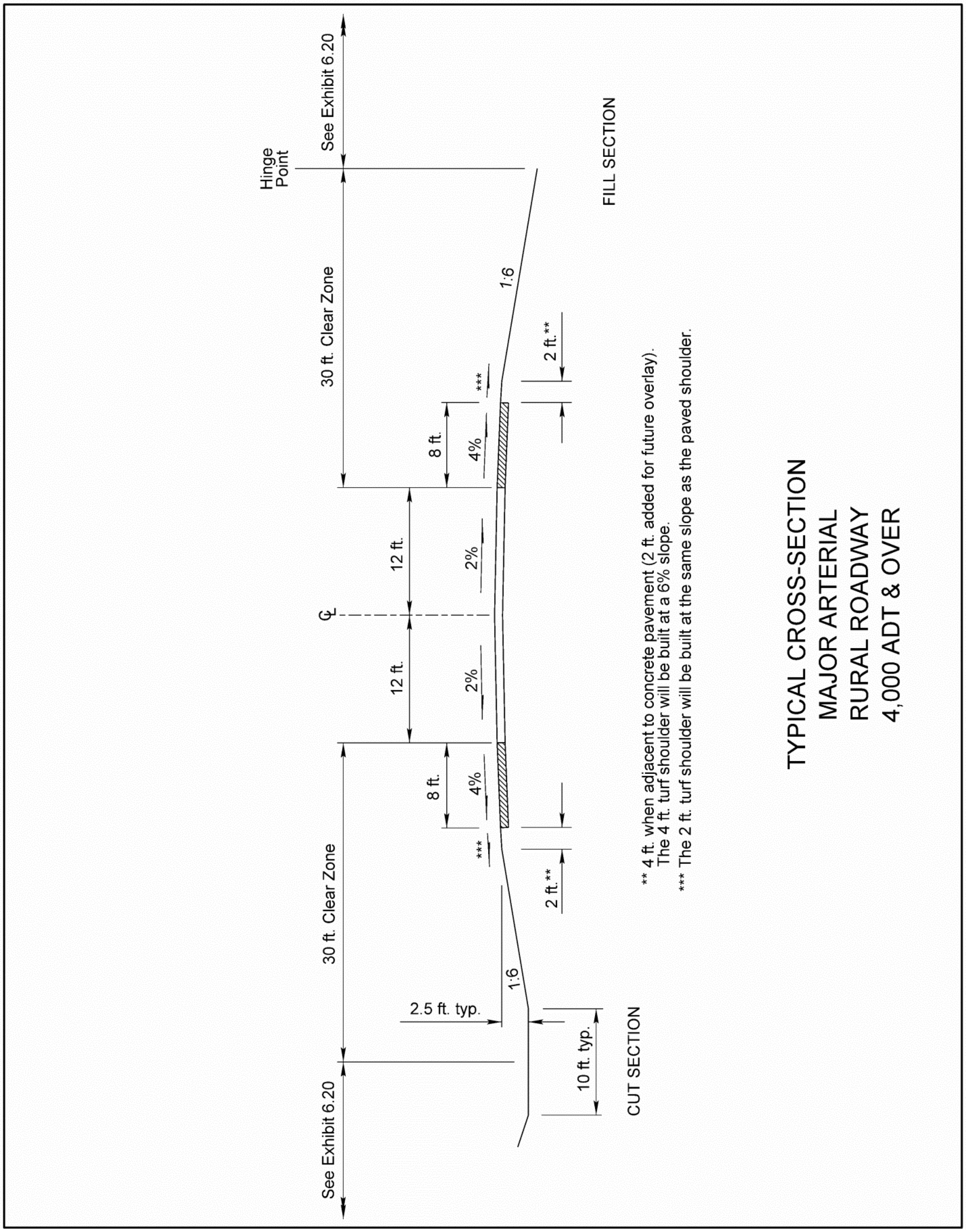


Exhibit 6.7 Typical Section - Rural Major Arterial 4,000 ADT and Over

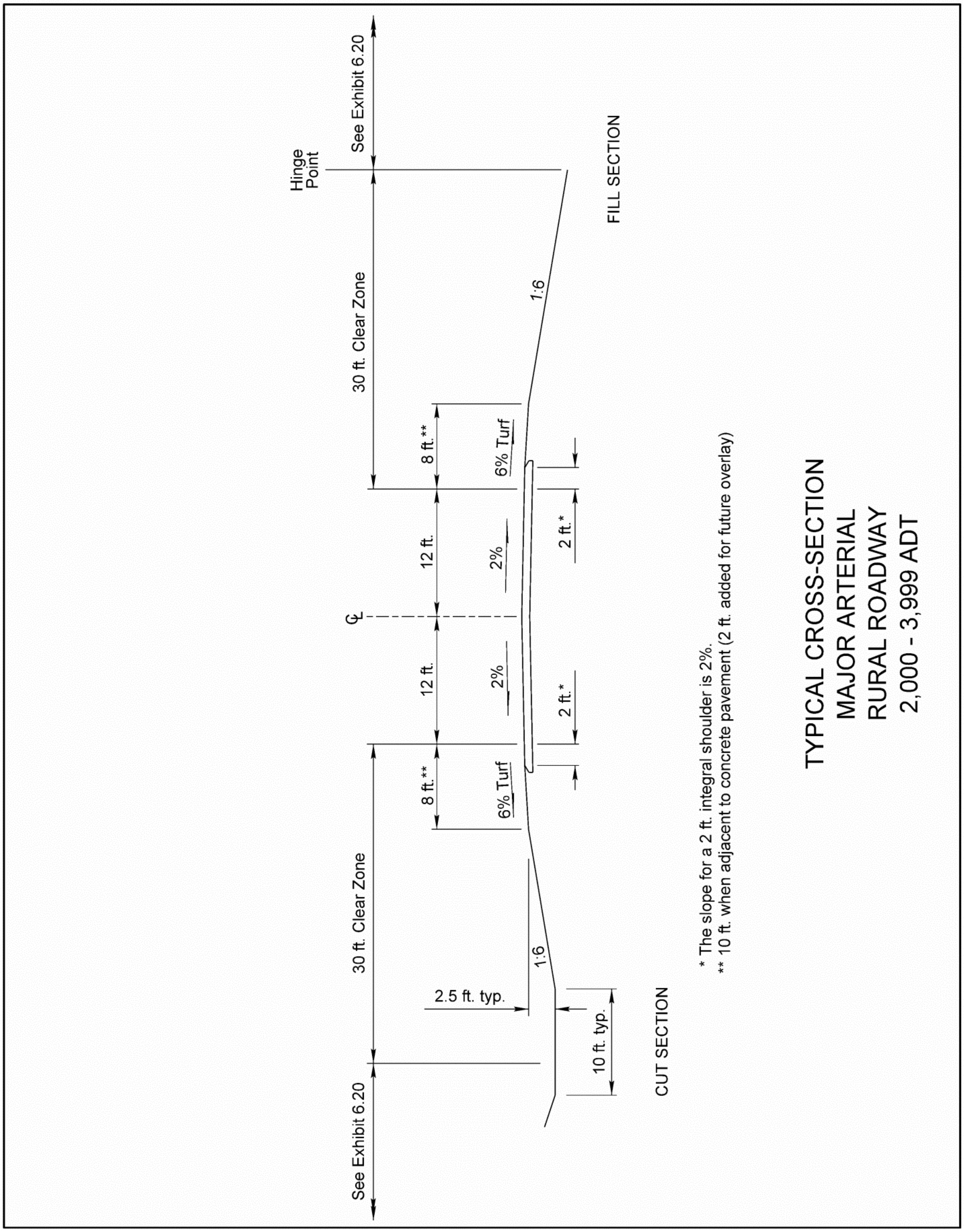


Exhibit 6.8 Typical Section - Rural Major Arterial 2,000 to 3,999 ADT

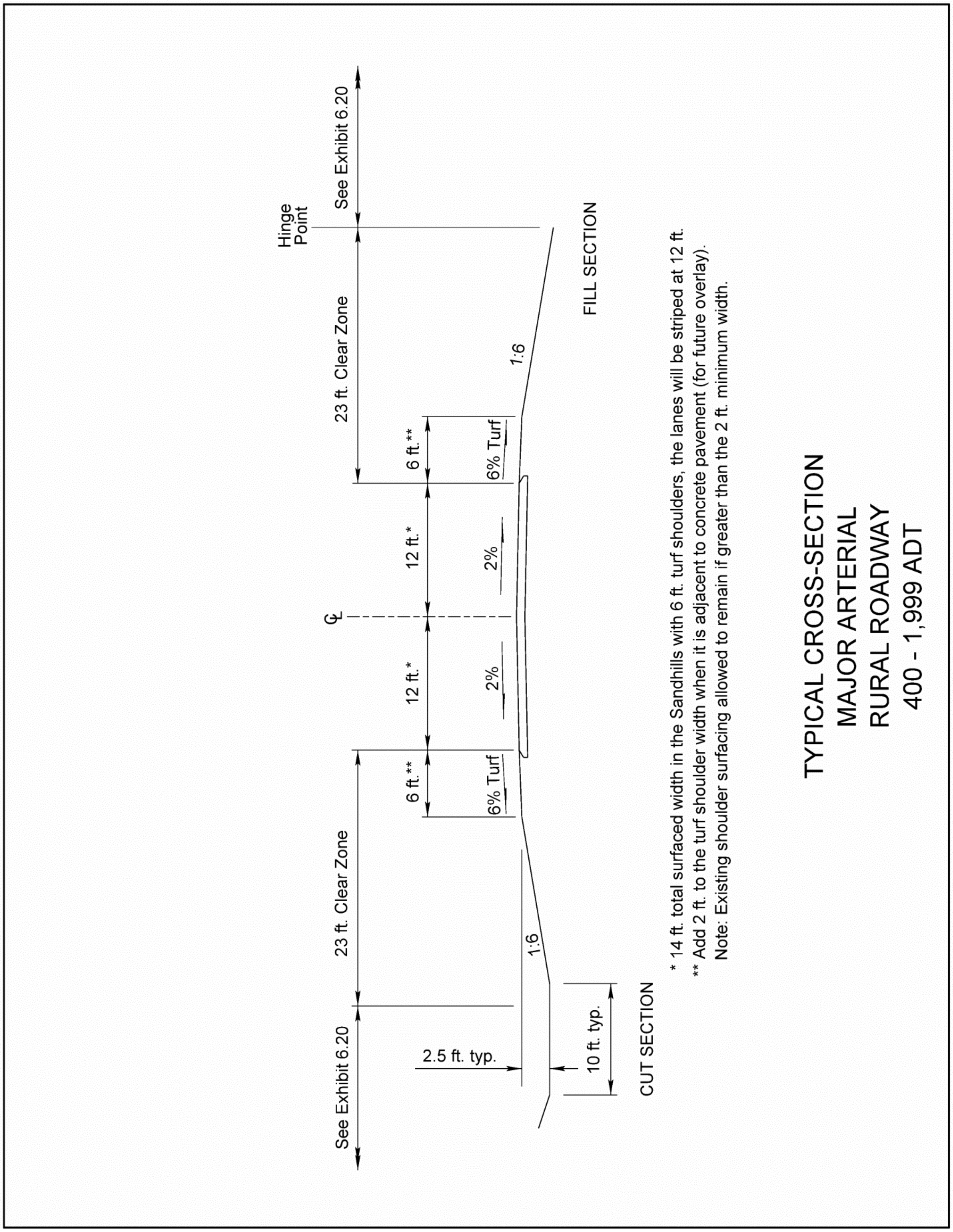


Exhibit 6.9 Typical Section - Rural Major Arterial 400 to 1,999 ADT

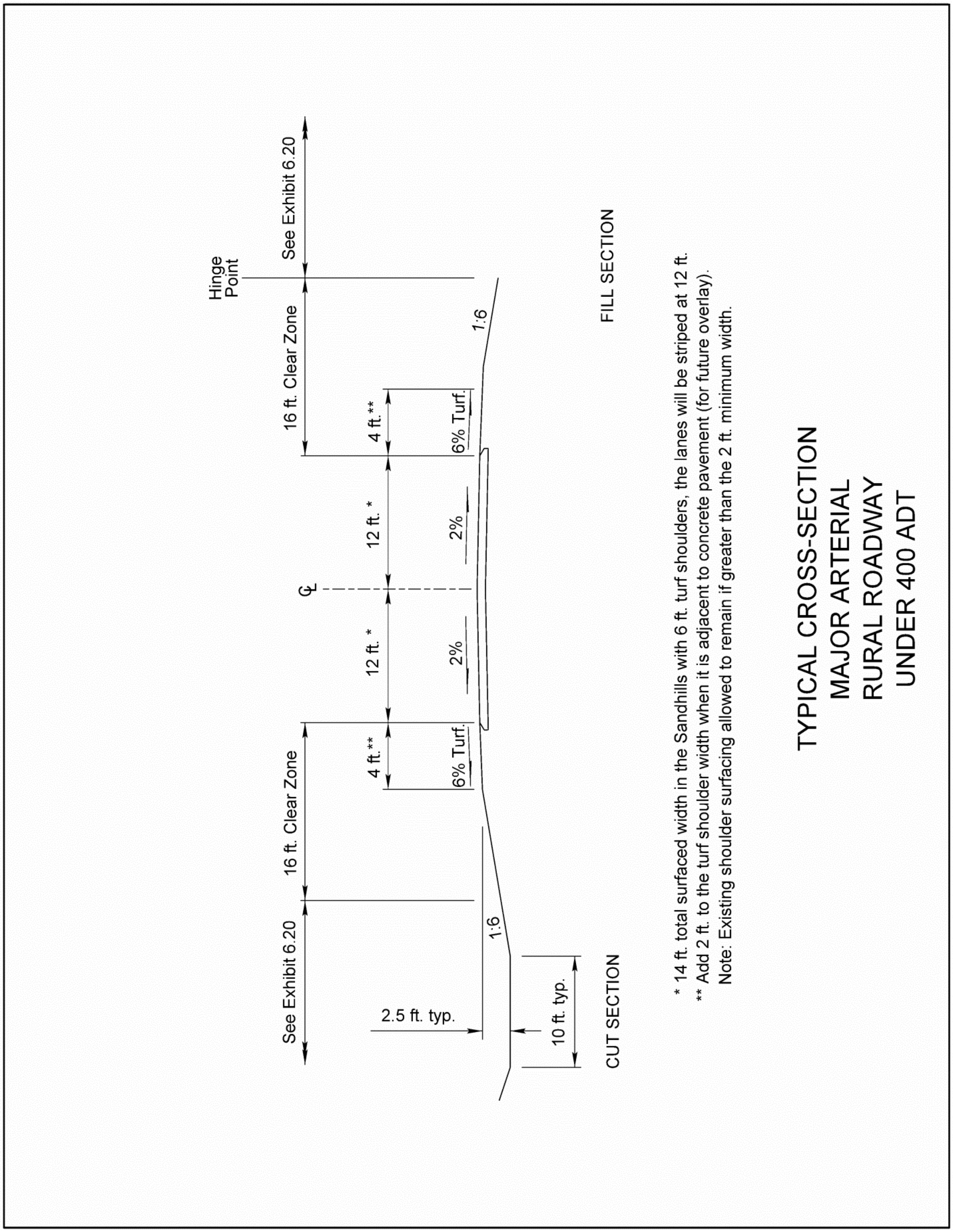


Exhibit 6.10 Typical Section - Rural Major Arterial Under 400 ADT

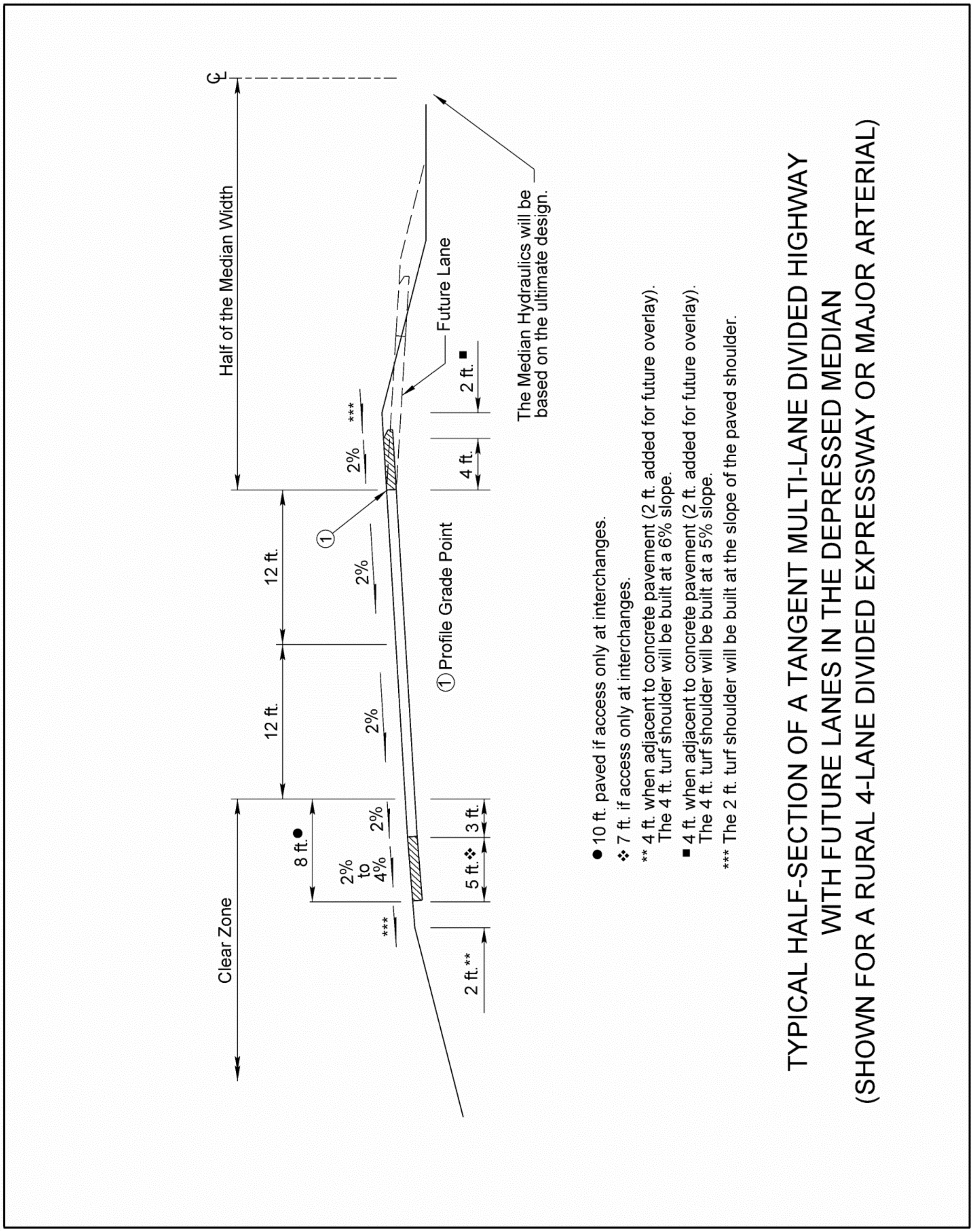


Exhibit 6.11 Typical Half-Section of a Tangent Multi-Lane Divided Highway with Future Lanes in the Depressed Median

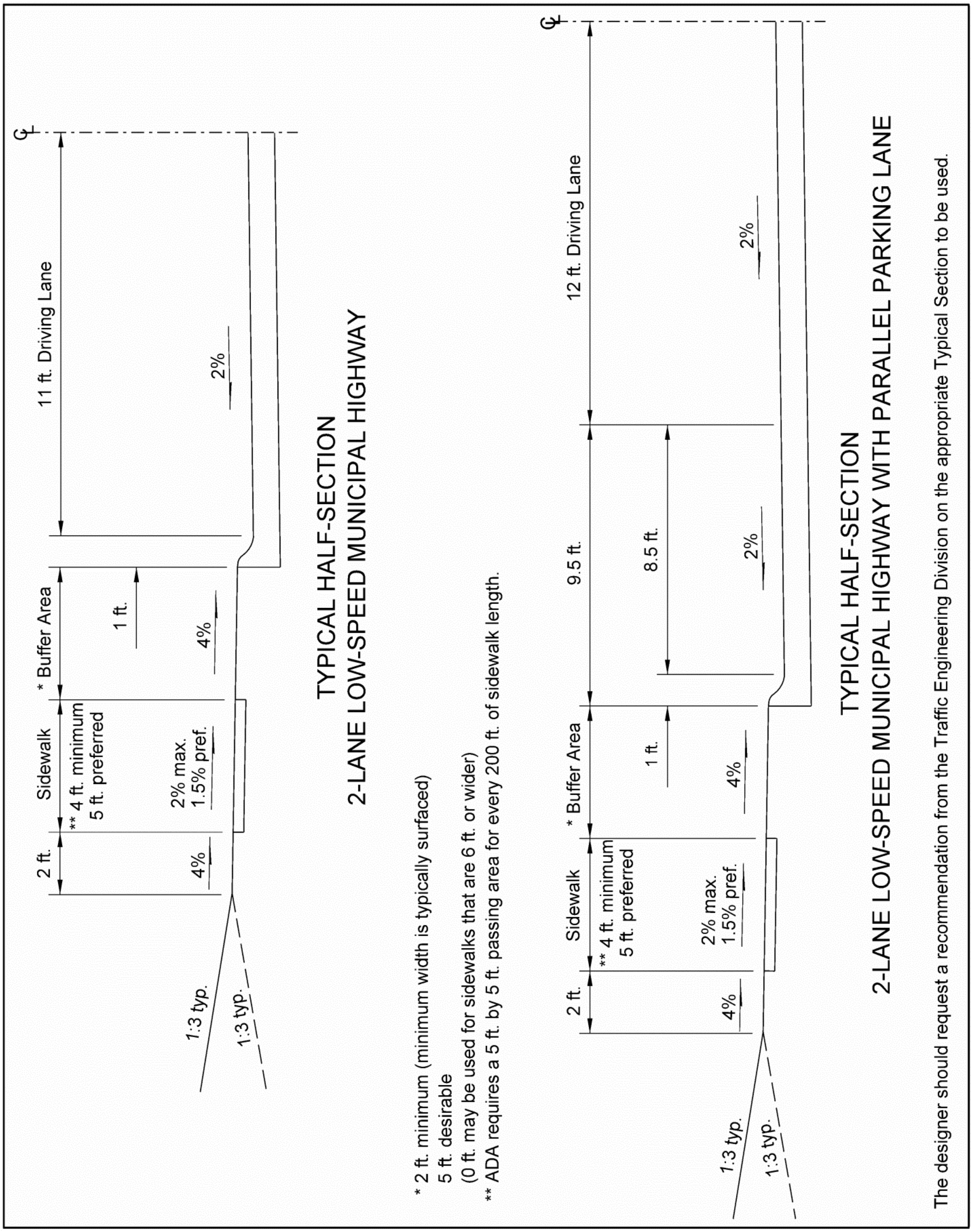


Exhibit 6.12 Typical Half-Sections of Two-Lane Low-Speed Municipal Highways

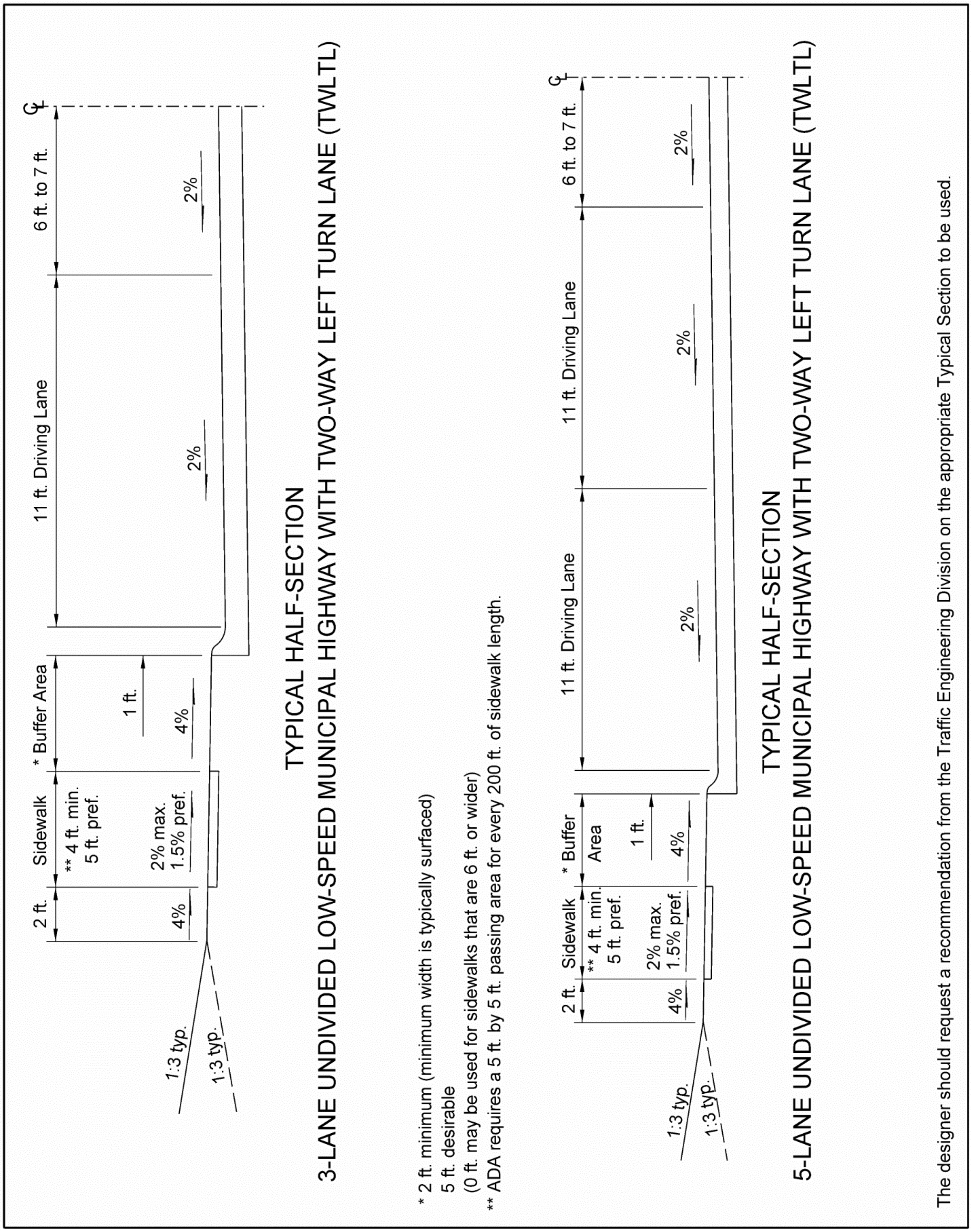


Exhibit 6.13 Typical Half-Sections of Three-Lane and Five-Lane Undivided Low-Speed Municipal Highways with Two-Way Left Turn Lanes

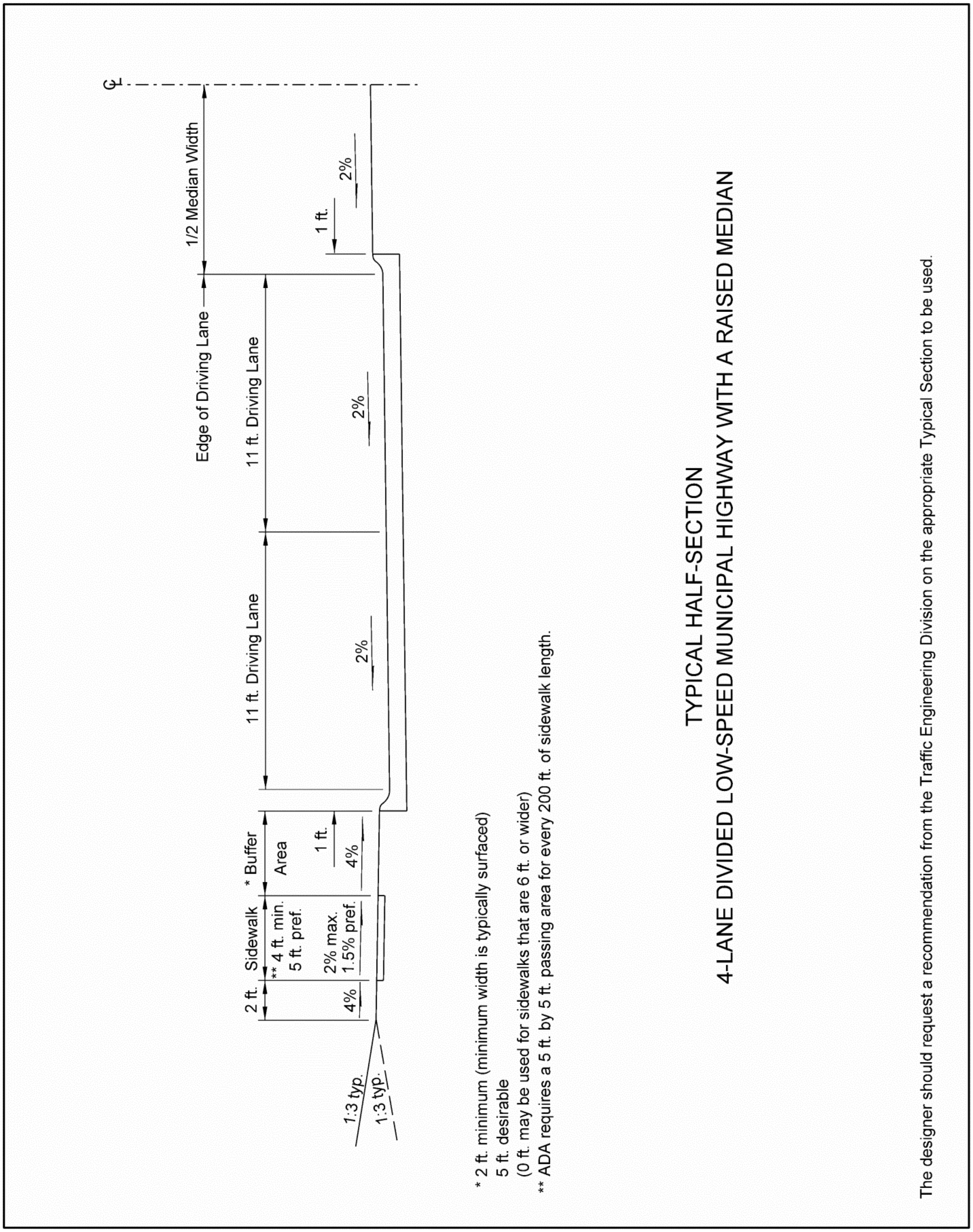


Exhibit 6.14 Typical Half-Section of a Four-Lane Divided Low-Speed Municipal Highway with a Twenty Feet Raised Median

3. CURBS

The type and location of curbs affect driver behavior and the utility of a highway. Most commonly found in urban areas, curbs may facilitate:

- Drainage
- Pavement edge delineation
- Delineation of pedestrian walkways
- Traffic channelization
- Access management

3.A Curb Warrants

The selection of a curbed roadway section depends on many factors including, but not limited to:

- Traffic management
- Design speed
- Urban/rural location
- Drainage
- Future or ultimate development
- Construction costs
- At a roundabout

Urban Locations - Curbed sections are typically used in urban locations due to:

- Traffic management
- Drainage requirements
- Right-of-way constraints
- Access management

Rural Locations - Curbs on rural highways may be warranted for the following conditions, as well as others:

- Traffic management
- Where a raised median is constructed
- Erosion control
- Right-of-way constraints

The need for and location of curbed sections should be discussed during the preliminary design.

3.B Curb Types

The three general types of curb are:

1. Barrier: Barrier curbs are relatively steep-faced and are intended to keep the vehicle from leaving the roadway.
2. Mountable: Mountable curbs (e.g. the integral concrete curb) are designed so that errant vehicles can cross them easily.
3. Slope: Sloping curbs are usually three or four inches in height with a simple angular rise. They are also designed to be easily crossed and are preferred over mountable curbs due to ease of hand construction.

Curbs are constructed of either Portland Cement Concrete or asphaltic concrete. Examples of various curb types are shown in EXHIBIT 6.16 and in the Standard/Special Plans Book (*Standard Plans*) (Ref. 6.3) (http://www.roads.nebraska.gov/business-center/design-consultant/stand-spec-manual/).

The following guidelines should be used to determine the appropriate curb height:

- High-speed roadways (design speed ≥ 50 mph): three inch asphaltic concrete curb, three inch concrete slope curb, or four inch concrete slope curb (See EXHIBIT 6.17).
- Low-speed roadways (design speed ≤ 45 mph): six inch curbs.
- Teardrop islands on side roads intersecting high-speed roadways: inside of the lateral obstacle clear zone of the mainline the curb will be three inch asphaltic concrete curb, three inch concrete slope curb, or four inch concrete slope curb (See EXHIBIT 6.15).
- Roundabouts: the splitter islands will be six inch integral concrete curb. A three inch truck apron curb will be used for the truck apron and a four inch sloping curb will be used for the inner circle of the center island (See EXHIBITS 6.16 AND 4.2).

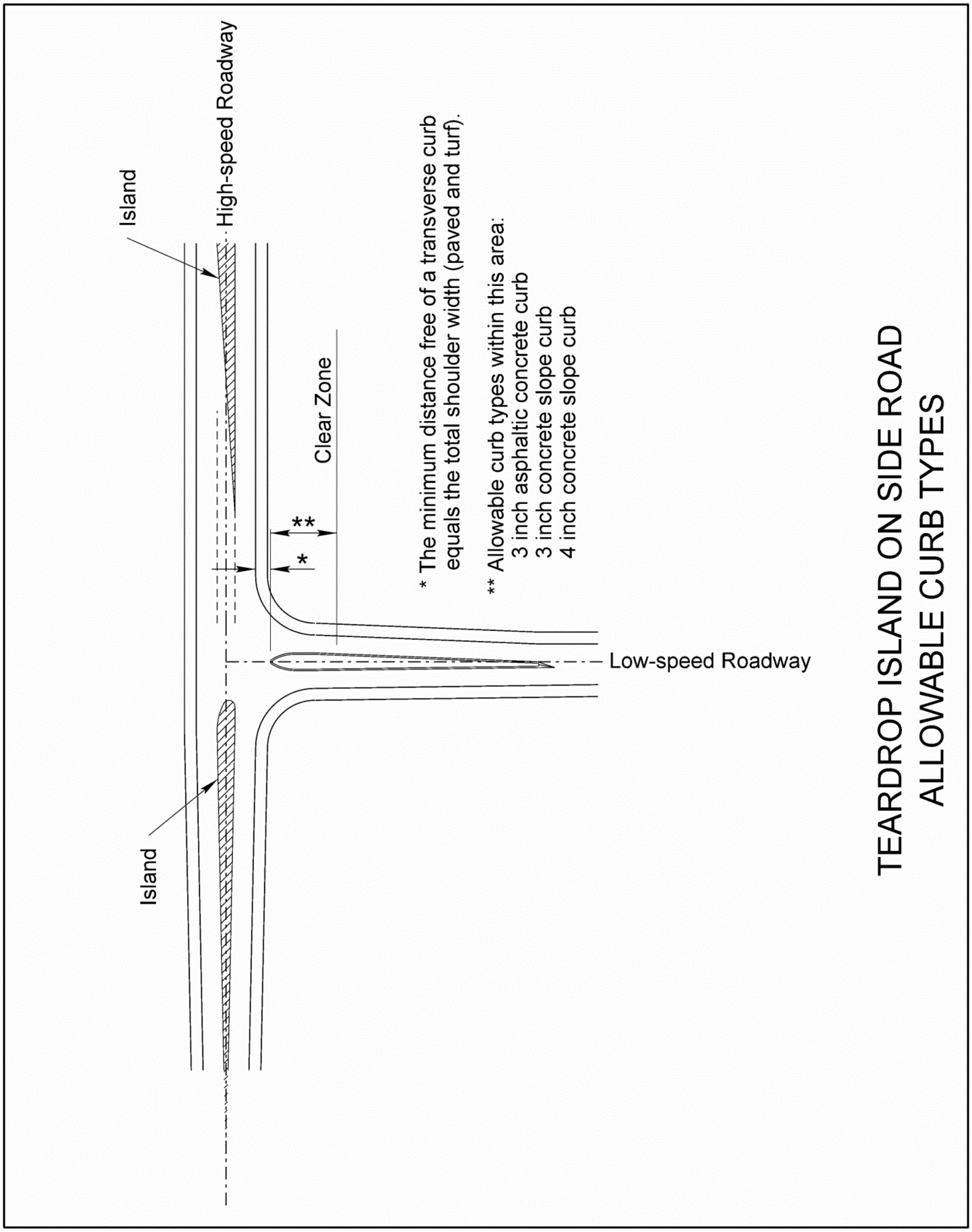


Exhibit 6.15 Teardrop Island on Side Road
Allowable Curb Types

3.C Curb Design Considerations

Drainage - Curb height influences hydraulic design and analysis (See the Drainage Design and Erosion Control Manual (*Drainage Manual*) (Ref. 6.4), Chapter One: Drainage, Section 10) (http://www.roads.nebraska.gov/business-center/design-consultant/rd-manuals/).

Roadside Geometry - Side slope configuration is based on whether a curbed or uncurbed section is used.

Transitions - EXHIBIT 6.18 illustrates the standard procedure for curbed to uncurbed transition.

Erosive Soils - Curb and concrete flumes may be installed on a project to protect earth shoulders and side slopes from stormwater runoff in regions where native soils are commonly susceptible to soil erosion (such as the Sandhills Region and loess soil areas) (See the *Drainage Manual* (Ref. 6.4), Chapter Two: Erosion and Sediment Control, Section 7.E).

Design Guidelines - The following guidelines have been developed for the design of curbed roadway sections:

1. When curbs are constructed, the top of the abutting turf or sidewalk should be at the same elevation as the top of the curb (See EXHIBITS 6.12, 6.13 AND 6.14).
2. When a curb is used in high-speed conditions (design speed ≥ 50 mph), the gutterline of the curb should be located six feet from the edge of the lane or at the edge of the surfaced shoulder width given in the *MDS* (Ref. 6.2), whichever is greater (See EXHIBIT 6.17). The curb may also be located flush with or behind a bridge railing or guardrail.
3. When curb and flume is constructed at the edge of the shoulder, the edge of the through traffic lane will be at the same elevation or higher than the top of the curb to prevent the spread of water onto the high-speed travel lane. The drainage will be designed to conform to the design spread criteria (See the *Drainage Manual* (Ref. 6.4), Chapter One: Drainage Design, EXHIBIT 1.37).
4. When erosion control or sloping curbs are constructed in rural areas the typical section will show the earth portion of the shoulder to be a minimum of two feet in width and finished to the top of the curb. Four feet wide turf shoulders are preferred if there is an erosion problem or if the project is in the Sandhills region (See EXHIBIT 6.17). A wider turf shoulder may be necessary if guardrail is installed at curbed sections.
5. Installing an erosion control curb does not change the clear zone requirements presented in the *MDS* (Ref. 6.2).
6. Curb cuts will be provided as required for existing and future access drives (See Chapter Four: Intersections, Driveways and Channelization, Section 2.B).

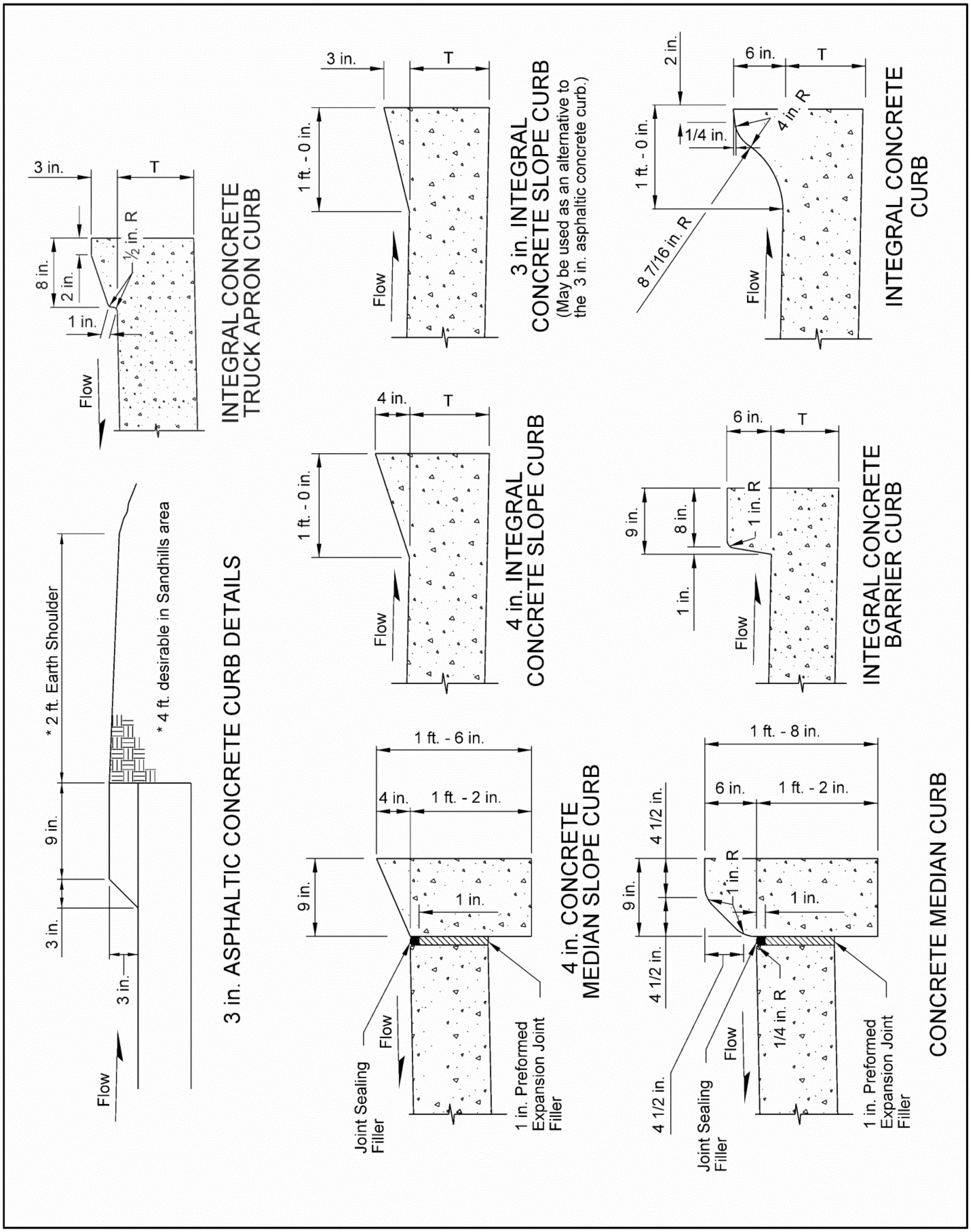
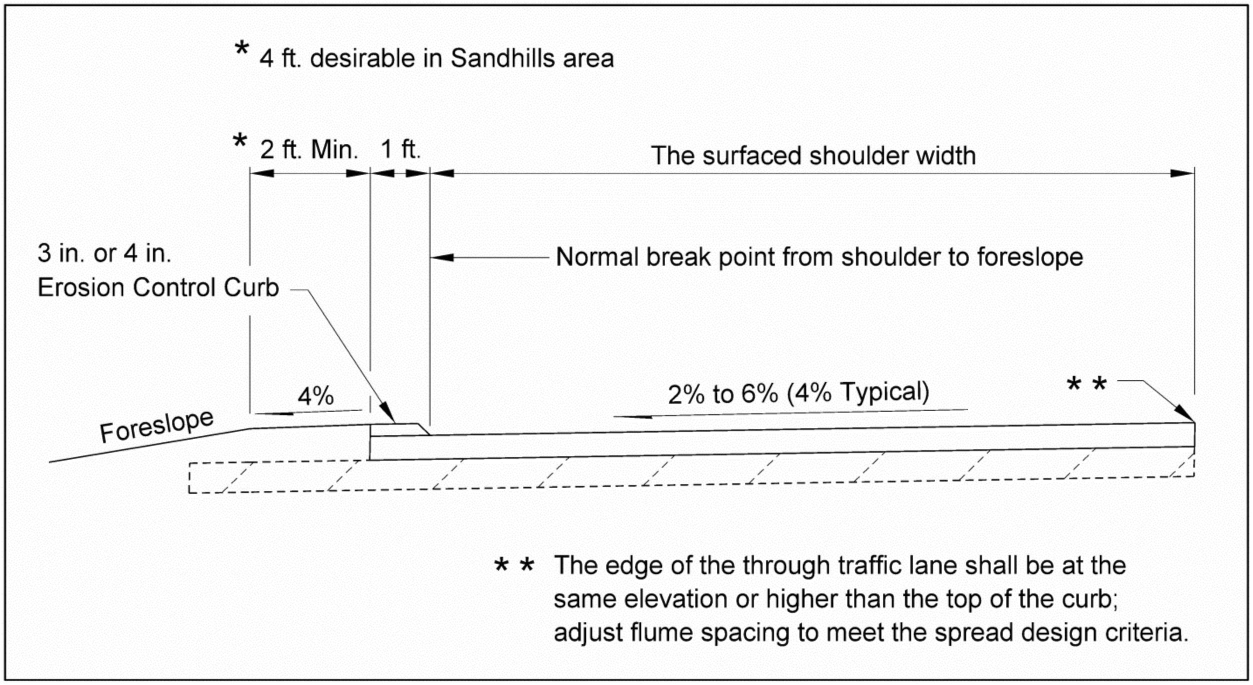
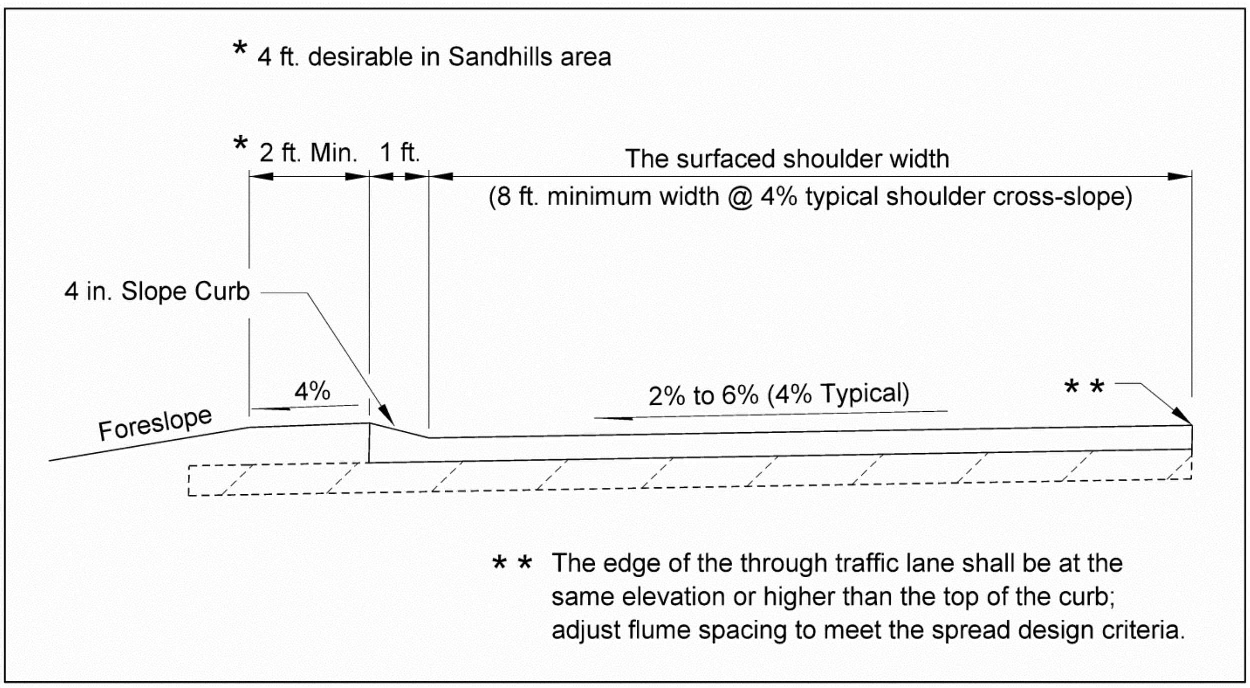


Exhibit 6.16 Typical Curb Details



3 inch or 4 inch Erosion Control Curb



4 inch Slope Curb

Exhibit 6.17 Erosion Control Curb Location

4. ROLLOVER RATES

The rollover rate is defined as the algebraic difference in rate of cross slope between adjacent paved surfaces. The maximum rollover rates used by the **NDOT** are:

- 5% between lanes for facilities with a design speed ≥ 50 mph
- 7% between the roadway and shoulder
- 5% for gore areas

The treatment of rollover through superelevated sections is shown in Chapter Three: Roadway Alignment, EXHIBITS 3.3a, 3.4a, & 3.5a.

For additional information see the *Green Book* (Ref. 6.1), Sections 4 and 9.

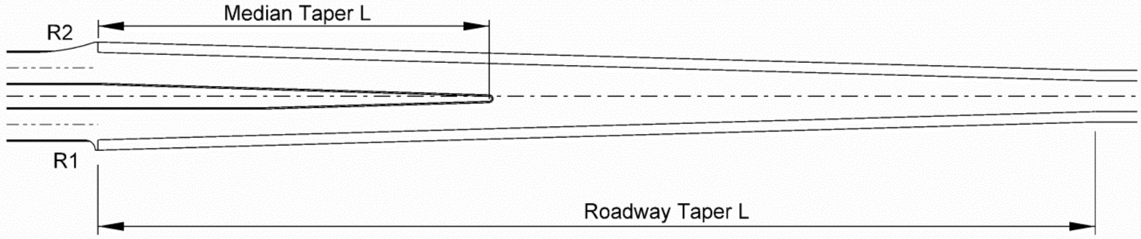
5. TRANSITION

Transition sections are required when one roadway cross-section changes to another roadway cross-section. Locations where transition sections are required include, but are not limited to:

- The change from standard roadway sections to roadway sections with auxiliary lanes
- The change from multilane facilities to two-lane facilities
- At narrow existing bridge structures
- At ramps and turning roadways
- The change from rural to urban sections

EXHIBIT 6.18 illustrates common lane transition configurations.

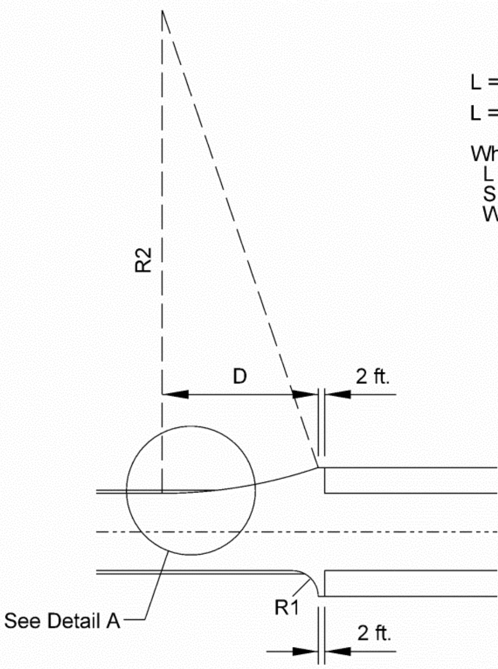
Transitions for auxiliary lanes, especially turning lanes, often depend on the space available for the transition. Specific criteria for auxiliary lane transition sections and taper rates are discussed in Chapter 4 of the *Green Book* (Ref. 6.1).



Two Lane Rural Section with Surfaced Shoulders
to Four Lane Municipal Section with Raised Median

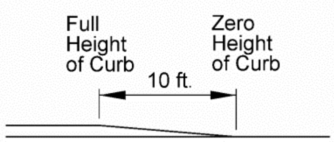
$L = WS$ for Speeds ≥ 50 mph
$L = WS^2 / 60$ for Speeds ≤ 45 mph

Where:
L = Minimum Length of Taper
S = Posted Speed Limit
W = Change in Width



Width of Surfaced Shoulders	R1	R2	D
6 ft.	6 ft.	150 ft.	42.0 ft.
8 ft.	8 ft.	150 ft.	48.3 ft.
10 ft.	10 ft.	150 ft.	53.8 ft.

Two Lane Rural Section with Surfaced Shoulders
to Two Lane Municipal Section



Detail A
Longitudinal Section Along
6 in. Curb at Terminal End

NOTES: Intersections, driveways or flume discharge structures will also suffice as a curb terminal point if their location permits.

Exhibit 6.18 Examples of Rural to Urban Roadway Transitions

6. AUXILIARY LANES

Auxiliary lanes may be added to a roadway for various reasons, including:

- Turn lanes at intersections
- Two-way left-turn lanes
- Truck climbing/passing lanes
- Acceleration/deceleration lanes
- Continuous auxiliary lanes between two closely spaced interchanges

For further information see Chapter Three: Roadway Alignment, Section 3.A.4, Chapter Four: Intersections, Driveways and Channelization, Section 1.D, and Chapter 4 of the *Green Book* (Ref. 6.1).

7. ROADWAY CHANNELIZATION

See Chapter Four: Intersections, Driveways and Channelization, Section 5 and the *Green Book* (Ref. 1.1), Sections 4.11 and 9.6.3.

8. NEW FOUR-LANE DIVIDED HIGHWAY USING EXISTING TWO-LANE HIGHWAY

The following guidance should be followed when designing a four-lane divided highway which utilizes the existing two-lane roadway:

1. The new lanes and median will be designed to expressway or major arterial crowned standards (See EXHIBIT 6.5).
2. For existing crowned sections with eight feet wide surfaced shoulders which are in relatively good condition, the inside (median) eight feet wide surfaced shoulder should be removed or reduced to four feet in width.
3. The location of the axis of rotation and the profile grade point through superelevated sections of the new lanes is illustrated in Chapter Three: Roadway Alignment, EXHIBITS 3.3, 3.4, 3.5, & 3.6.
4. A depressed median should have sufficient width (edge of the driving lane to edge of the driving lane) to provide for proper drainage (a minimum width of 50 feet is typical for four feet wide surfaced inside shoulders with 1:6 fill slopes). For additional information see Chapter Four: Intersections, Driveways and Channelization, Section 5.

9. ROADSIDE DESIGN

9.A The Clear Zone

In the late 1960's the forgiving roadside concept was introduced, recognizing that motorists do run off of the roadway and that the number of serious accidents and injuries might be lessened if a traversable recovery area were provided. Ideally this recovery area, the clear zone, should be free of obstacles such as unyielding sign and luminaire supports, trees, non-traversable drainage structures, utility poles, steep slopes, etc. Design options for the treatment of these features have generally been considered in the following order:

- Remove the obstacle or redesign it so it can be traversed
- Relocate the obstacle to outside of the clear zone or to where it is less likely to be struck
- Reduce impact severity by using an appropriate breakaway device
- Redirect a vehicle by shielding the obstacle with a longitudinal traffic barrier and/or impact attenuator
- Delineate the obstacle if other alternatives are not practicable

Clear zone width varies with the roadway functional classification, project type, traffic volume, design speed, roadway location, and the grading section of the roadway. The *MDS* (Ref. 6.2) provides the **NDOT** minimum clear zone requirements for various roadway types. For additional information, see Chapter 3 of the Roadside Design Guide (Ref. 6.6).

9.A.1 Horizontal Clear Zone

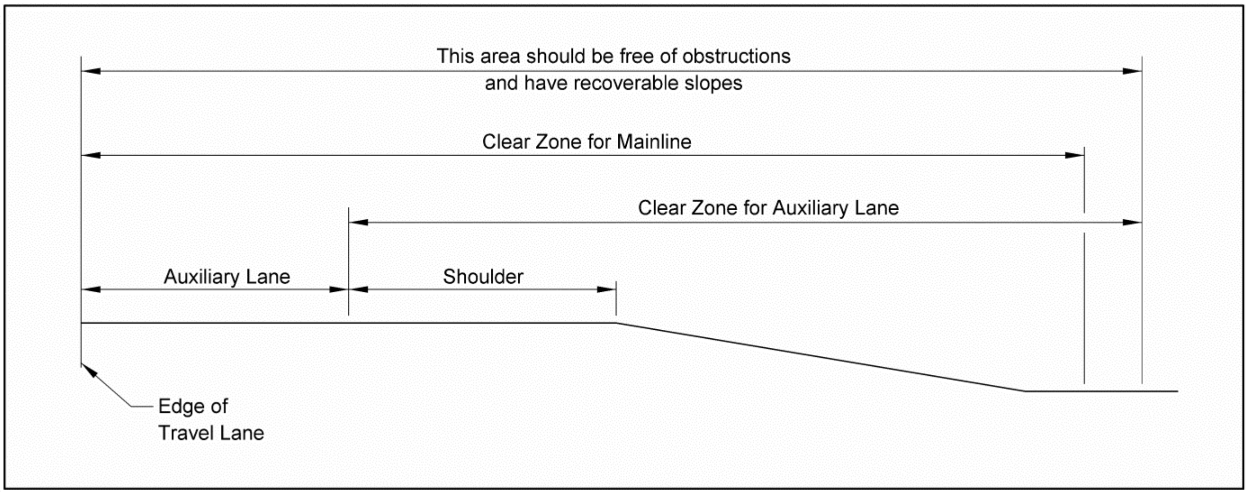
For new and reconstructed projects the horizontal clear zone is the roadside area, starting at the edge of the travel lane, which is available for the recovery of errant vehicles. It may consist of the shoulder, a recoverable slope, a non-recoverable but traversable slope, and/or a clear runout area. The required horizontal clear zone will vary depending upon the roadway classification (See the *MDS*, Ref. 6.2).

9.A.2 Fixed Obstacle Clearance

For 3R projects the fixed obstacle clearance, as given in the *MDS* (Ref. 6.2), provides an obstacle free zone in the roadside environment. For additional information see Chapter Seventeen: Resurfacing, Restoration and Rehabilitation (3R) Projects.

9.A.3 Clear Zone Requirements for Auxiliary Lanes

In some instances it will be necessary to calculate clear zone requirements for both the mainline driving lane and for an auxiliary lane. The clear zone must be calculated for each lane independently, based on the projected traffic volumes and design speeds of the individual lanes (See **TABLE 3.1** of the Roadside Design Guide, Ref. 6.6). The clear zone will be set at the greater of the two distances from the edge of travel way, as shown in EXHIBIT 6.19.



Note: Use the larger clear zone as measured from the edge of the travel lane or from the edge of the auxiliary lane.

Exhibit 6.19 Clear Zone Application for Auxiliary Lanes Adjacent to Mainline

9.B Roadside Geometry (Side Slopes)

The roadside geometry (foreslopes and backslopes) depends on many factors, including:

- The functional classification of the roadway
- Topography
- Urban/rural location
- The presence of curbs
- Snow Control

Criteria for roadside geometry for municipal highways are illustrated in EXHIBITS 6.12, 6.13 AND 6.14. The grading typical sections for rural projects are illustrated in EXHIBIT 6.20. Variations from the typical grading section will require the approval of the **ADE** and the reasons for the variation will be documented in the project file. For additional information regarding roadside geometry, see Section 3.2 of the Roadside Design Guide (Ref. 6.6).

9.B.1 Fill Slopes (Parallel)

Fill slopes within the clear zone should be recoverable slopes (1:4 or flatter) with no protruding fixed objects. Motorists on recoverable slopes generally can either stop their vehicles or slow them sufficiently to enable a return to the roadway. For new and reconstructed projects the **NDOT** requires 1:6 or flatter slopes to the outside edge of the horizontal clear zone (which is also known as the hinge point).

A non-recoverable traversable slope is defined as a slope which is steeper than 1:4 but equal to or flatter than 1:3. Motorists on non-recoverable traversable slopes generally will not be able to stop their vehicles or return to the roadway but should be able to reach the bottom of the slope without overturning. A section of non-recoverable traversable slope may be contained within the clear zone as long as an unobstructed runout area (which is 1:4 or flatter) is provided beyond the non-recoverable slope (this runout width will be included in the total recovery area).

A side slope which is steeper than 1:3 is considered to be a critical slope (non-recoverable and non-traversable, one on which a vehicle is more likely to overturn). A critical slope should not be included within the clear zone. If a critical slope cannot be eliminated from the clear zone an analysis of the slope will be performed using an applicable computer program (such as RSAP) to determine the economic benefit of installing a safety barrier system (See Chapter Nine: Guardrail and Roadside Barriers, Section 1.D).

9.B.2 Fill Slopes (Transverse)

Transverse fill slopes caused by the grading at crossroads, driveways/field entrances, median crossings, dikes, etc. are generally more critical to vehicles traveling on the mainline than parallel slopes since the transverse slope is head on to an errant vehicle. Transverse fill slopes of 1:6 or flatter are required in depressed medians and within the clear zone on high-speed roadways (≥ 50 mph) (the **NDOT** prefers a transverse slope of 1:10 or flatter). The transverse fill slope will be carried to the outside edge of the clear zone and may then be warped to a 1:3 foreslope in a minimum distance of 15 feet (See EXHIBITS 4.14, 4.15 & 4.18).

9.B.3 Cut Slopes

Typical cross-sections of cut slopes can be found in EXHIBIT 6.20. The 10 foot ditch bottom should be considered as the desirable ditch width. This width may be reduced when encountering front yards, mature shelterbelts or trees, center pivots and at other locations where there would be major damages to the property if right-of-way would be acquired based on the 10 feet ditch width. The designer may consider installing curb and/or culvert pipe, when practicable, to reduce right-of-way damages; however, right-of-way should be acquired to or beyond the limits of the clear zone.

The foreslope of a cut section with a special ditch (see Section 10.B) should meet the same slope and height criteria as the fill slope requirements presented in EXHIBIT 6.20. Ditches with steep backslopes, such as bench cuts through rock, should be designed so that the backslope is outside of the clear zone.

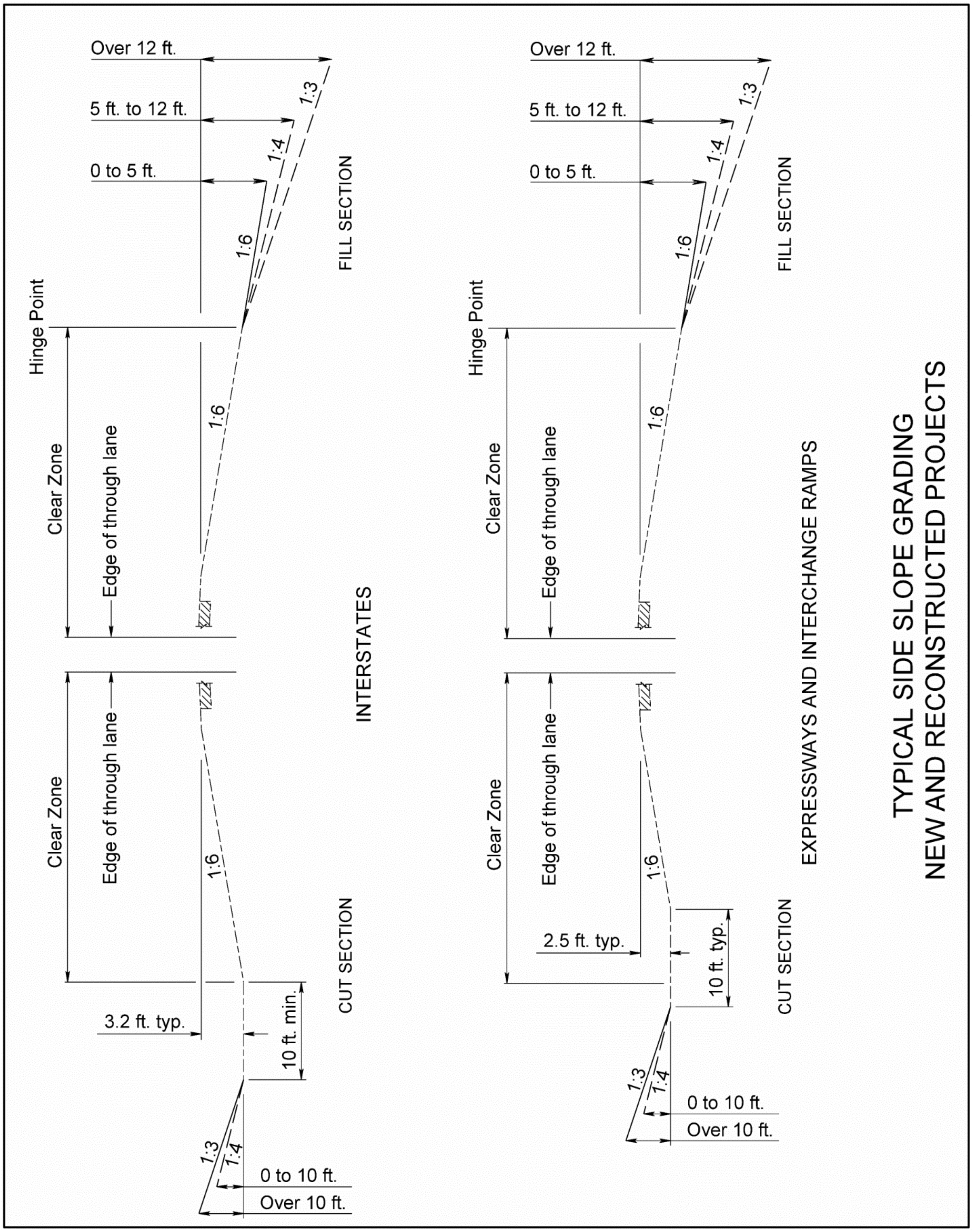


Exhibit 6.20a Typical Side Slopes for New and Reconstructed Projects

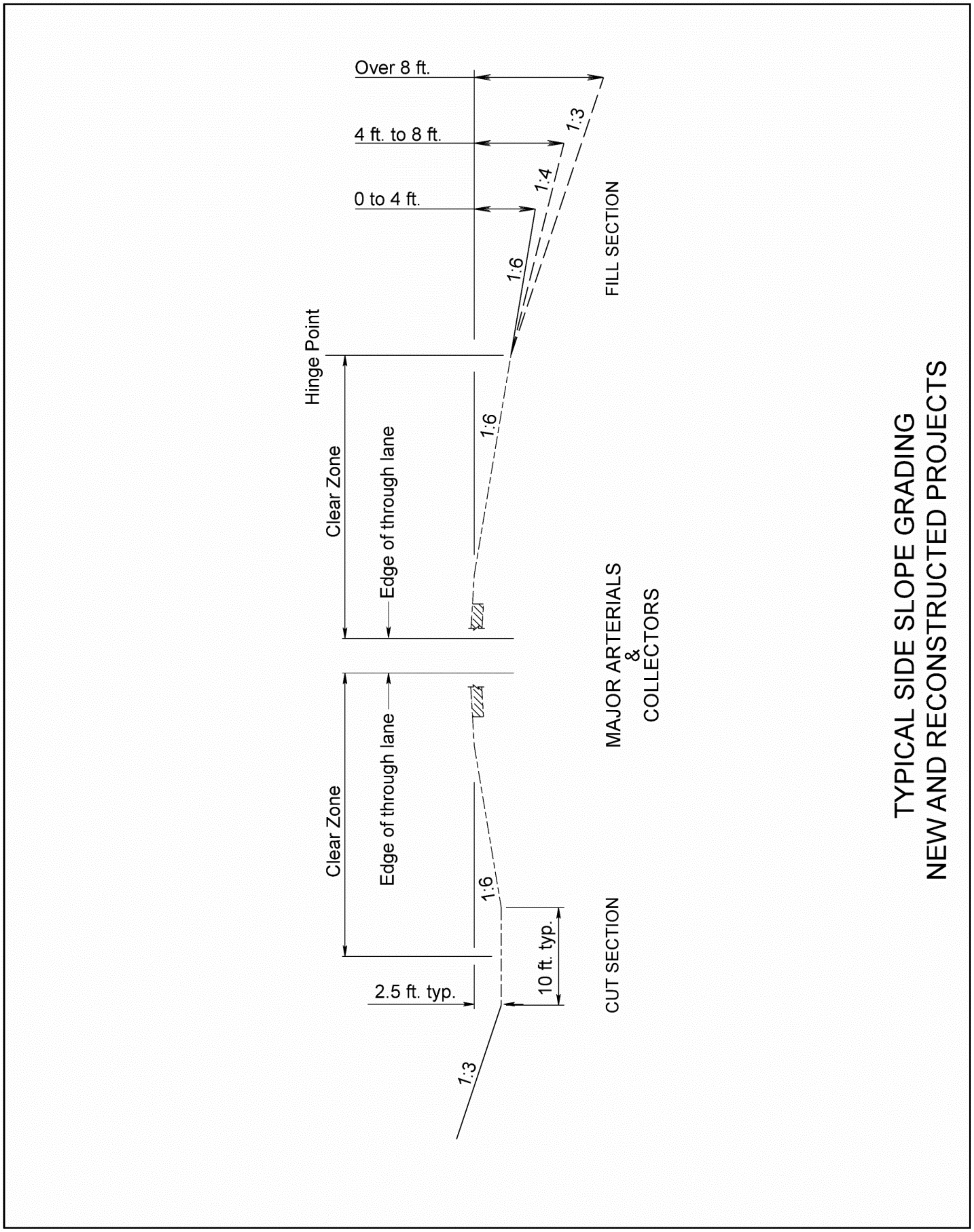


Exhibit 6.20b Typical Side Slopes for New and Reconstructed Projects

10. OTHER ELEMENTS AFFECTING THE ROADWAY CROSS-SECTION

10.A Right-of Way

Right-of-way requirements for street and highway design are discussed in Chapter Fifteen: Right-of-Way, Section 2.C.1. Right-of-way considerations which may impact the design of the roadway cross-section include, but are not limited to:

- Restricted Right-of-Way - Areas where right-of-way is restricted (e.g. environmental considerations, buildings) may require the use of steeper side slopes, retaining walls, adjustments to the vertical grade to reduce fill heights, and/or the provision of roadside barriers.
- Sight Distance - The purchase of additional right-of-way may be warranted at horizontal curves and intersections to provide and/or maintain the required horizontal sight distances.
- Constructability – Construction easements may be required for construction of bridge structures, for construction equipment access and storage, for materials storage and for other activities required for the construction of the project.

10.B Drainage

A roadside ditch will be of sufficient depth to meet the maximum allowable headwater (D + 1) policy (See the *Drainage Manual* (Ref. 6.4), Chapter One: Drainage, Section 8.G).

Ditches which are greater than the normal depths shown in EXHIBITS 6.1 THROUGH 6.10 AND 6.20 are referred to as special ditches. When placing a special ditch the designer should use a 1:6, 1:4, or a 1:3 foreslope as specified in EXHIBIT 6.20; the grading may go directly to a 1:3 foreslope from the hinge point with **Unit Head** approval and a decision letter to the project file. The minimum special ditch length that will be shown on the Plan and Profile Sheet is 150 feet (See Chapter Eleven: Highway Plans Assembly, Section 4.J); the grading contractor will build shorter special ditches based on the project slope stake data. The roadway designer will inform the **Roadside Development Unit** in the **Project Development Division** (**PDD**) of the location and slope of all ditches for their use in the design of the erosion control.

For curbed facilities, the type of facility limits the maximum width or spread of stormwater from the curb onto the roadway (see EXHIBIT 1.37 of the *Drainage Manual*, Ref. 6.4). Curb height, superelevation, and longitudinal slope all impact drainage design for curbed facilities.

Drainage design is discussed in Chapter One: Drainage of the *Drainage Manual* (Ref. 6.4).

10.C Environmental Considerations

It may be necessary to adjust the project side slopes to avoid impacting environmentally sensitive areas. The **Environmental Section** of **PDD** should be consulted about specific problem areas associated with the roadside landscape. Typical environmental considerations that may impact cross-section design include:

- Rare and/or endangered plant species (e.g. Prairie Fringed Orchid)
- Saving established vegetation on existing slopes, where practicable, in the Sandhills Region
- Saving existing trees which are outside of the clear zone but are within the project construction limits, where desired
- Avoiding excavation inside the dripline of a tree, which will damage its roots, if the tree is to be saved (the dripline is the perimeter of the area directly under the crown of the tree)

See Chapter Ten: Miscellaneous Design Issues, Section 3, for further information.

Changes to the roadway cross-section as it is described in the approved environmental (NEPA) document shall be submitted to the **Environmental Section** in **PDD** for review. For additional information, see Chapter Thirteen: Planning and Project Development.

10.D Erosion Control

Erosion control considerations which may impact the design of the roadway cross-section include, but are not limited to, the following:

- Building curb and flume (See Section 3.C)
- Providing flatter side slopes, where practicable, in the Sandhills Region and other areas where roadway side slopes are susceptible to erosion
- MS4 grass swales

See Chapter Two: Erosion and Sediment Control and Chapter Three: Stormwater Treatment of the *Drainage Manual* (Ref. 6.4) for additional information.

10.E Geotechnical Features

Geotechnical features within a project may impact cross-section design. The designer should review the soil, subgrade, and materials surveys from the **Materials and Research Division** (**M&R**) (See Chapter Seven: Earthwork, Section 6). Some features which may require special consideration include:

1. Cut or fill sections where the maximum height of cut or fill exceeds 20 feet or where embankment is to be constructed on a weak and compressible foundation material. These concerns are generally discussed in the foundation report and will affect construction phasing.
2. Soil and rock instability in cut/fill sections or natural slopes which are presently or potentially unstable, slide areas, slip plains, and unusual groundwater conditions. Mitigations for unstable conditions, such as geotextile soil reinforcement, permanent ground anchors, wick drains, stone columns, etc. may warrant special consideration.
3. Retaining walls where the maximum height along the length of a geotechnical feature exceeds four feet. Retaining wall design is discussed in Chapter Ten: Miscellaneous Design Issues, Section 7).

10.F Snow Control

Ditches may be widened and the backslope laid back from its normal 1:3 slope to provide more area for snow accumulation. See Chapter Ten: Miscellaneous Design Issues, Section 4, for a discussion of snowdrift abatement techniques.

10.G Earthwork Balances

Ditches or shoulders may be widened to provide for additional excavation or fill in order to balance the project earthwork (See Chapter Seven: Earthwork, Section 1).

10.H Daylighting

Daylighting occurs when the roadway backslope is flattened to intersect with the natural ground at a lower elevation than the typical backslope (See EXHIBIT 6.21). Daylighting may be used in order to gain excavation, to improve sight distance, or to eliminate snow drifting. When daylighting is used the following considerations should be taken into account:

- The consequences of removing the earth barrier related to impacts to environmentally sensitive areas, noise pollution, off-roadway glare, driver distraction, view from the roadway and from off of the roadway, and other aesthetic considerations
- Additional right-of-way may be required
- Current drainage patterns will be maintained

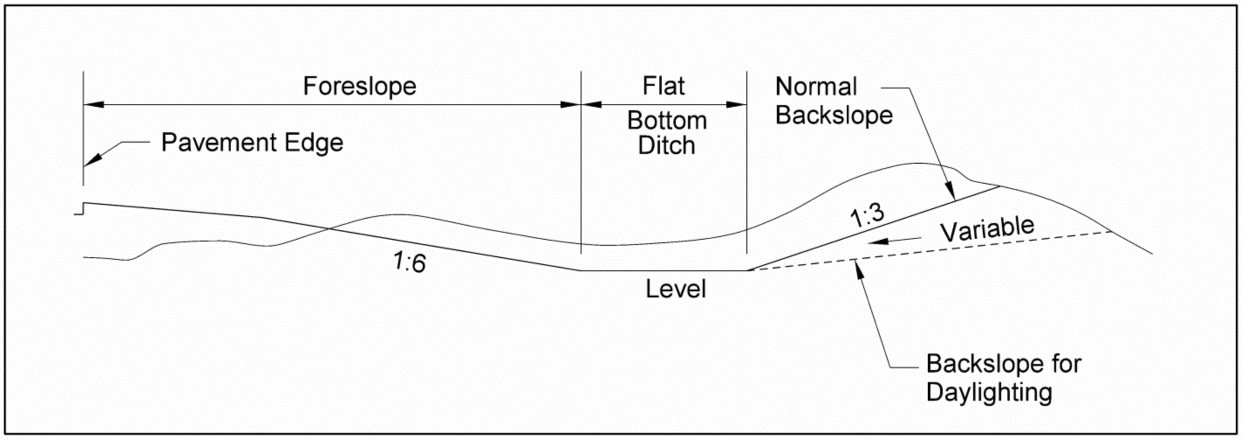


Exhibit 6.21 Daylighting

10.I Utilities

Highway and street improvements, whether within the existing right-of-way or on new right-of-way, generally entail adjustments of utility facilities. See Chapter Thirteen: Planning and Project Development, Section 6, for further information.

10.J Guardrail

Grading for guardrail may affect the roadway cross-section. See Chapter Nine: Guardrail and Roadside Barriers, Section 3.F, and the *Standard Plans* (Ref. 6.3) for further information.

10.K Bridges

The **Bridge Division** (**Bridge**) is responsible for the design of bridges and bridge-sized structures; the designer will coordinate with **Bridge** on projects involving bridges and bridge-sized structures (See Chapter Ten: Miscellaneous Design Issues, Section 2). Minimum bridge widths may be found in the *MDS* (Ref. 6.2).

10.K.1 Underpasses

The cross-section through an underpass should be the same as the approach roadway cross-section, including the clear zone or roadside barriers. Future widening of the roadway should be considered if significant traffic volume increases are anticipated in the foreseeable future (provide sufficient additional width for an additional lane in each direction to be added at a later date).

11. REFERENCES

6.1 American Association of State Highway and Transportation Officials, A Policy on Geometric Design of Highways and Streets (*Green Book*), Washington D.C., 2011.

6.2 Board of Public Roads Classifications and Standards, Nebraska Minimum Design Standards (*MDS*), Current Edition. (http://www.roads.nebraska.gov/business-center/lpa/boards-liaison/design-standards/)

6.3 Nebraska Department of Transportation, Standard/Special Plans Book (*Standard Plans*), Current Edition. (http://www.roads.nebraska.gov/business-center/design-consultant/stand-spec-manual/)

6.4 Nebraska Department of Transportation, Drainage Design and Erosion Control Manual (*Drainage Manual*), Current Edition. (http://www.roads.nebraska.gov/business-center/design-consultant/rd-manuals/)

6.5 Federal Highway Administration, Manual on Uniform Traffic Control Devices, (*MUTCD*) 2009. (http://www.roads.nebraska.gov/business-center/contractor/mutcd/)

6.6 American Association of State Highway and Transportation Officials, Roadside Design Guide, Washington D.C., 2011.